MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 2, 2015/2016

ETM7136 – DIGITAL COMMUNICATION SYSTEMS AND DESIGN

(M.Eng.Tele)

MARCH 2016
9.00 a.m - 12.00 p.m
(3 Hours)

INSTRUCTIONS TO STUDENTS

1. This Question paper consists of 8 pages (including the cover page) with 4 Questions only.

2. Attempt all of the **FOUR** questions. All questions carry equal marks and the distribution of the marks for each question is given.

3. Please write all your answers in the Answer Booklet provided.

Question 1

(a) Determine the Fourier transform of the following signal:

$$s(t)=\begin{cases} e^{-5t}, & t>0 \\ 0 & t<0 \end{cases}.$$

[5 marks]

(b) Consider a digital wireless communication system that utilizes a bandwidth of 5 MHz and operates at a signal-to-noise ratio (SNR) of 12 dB. Can the system achieve error-free transmission at a bit rate of 40 Mbps? If it is not possible, propose a solution without increasing the signal power. Justify your answer.

[5 marks]

(c) Given a nonperiodic, finite energy waveform $w(t)$ with the magnitude spectrum $W(f)$ shown in Figure Q1.

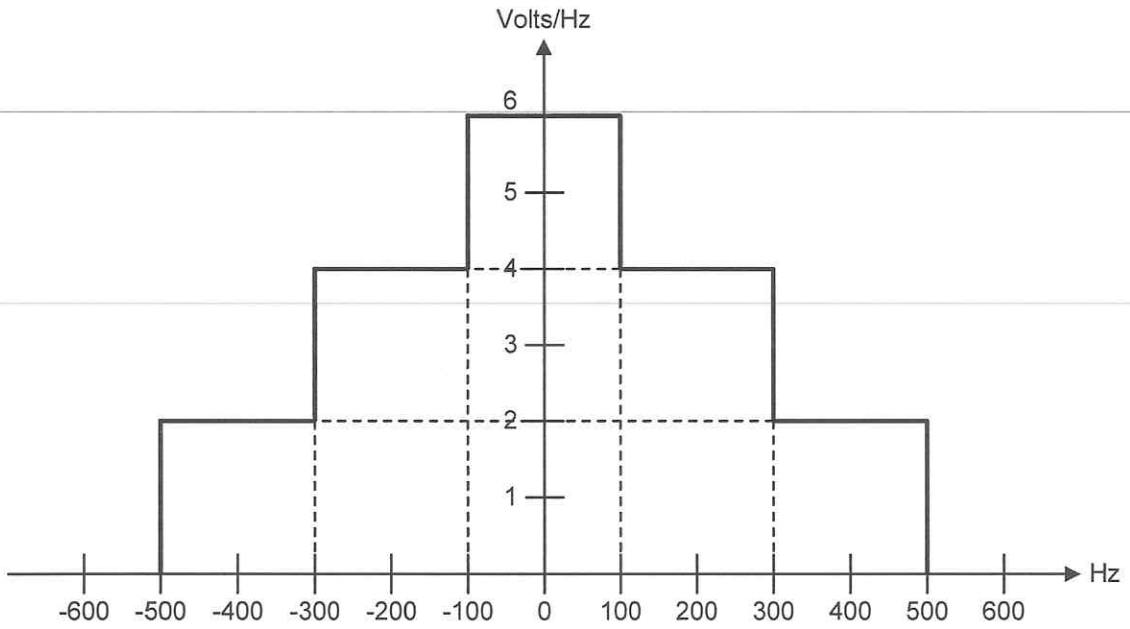

Figure Q1: Magnitude spectrum of $w(t)$.

(i) Calculate the normalized energy of the waveform.

[3 marks]

(ii) If $w(t)$ is passed through an ideal lowpass filter with a cutoff frequency of 150 Hz, calculate the normalized energy of the waveform at the output of the filter.

[3 marks]

(iii) What percentage of the signal's energy lies in the frequency band passed by the filter?

[1 mark]

Continued .....

Question 1

(d) A signal $y(t) = 5\cos(3000t) + 3\cos\left(2000t + \frac{\pi}{3}\right) + 2\cos\left(1000t + \frac{\pi}{6}\right)$ is to be uniformly sampled for digital transmission.

(i) Compute the minimum sampling frequency for $y(t)$ to avoid aliasing.

[3 marks]

(ii) Determine the maximum permissible time interval between sample values that will ensure perfect signal reproduction.

[1 mark]

(iii) Calculate the number of sample values needed for storage if $y(t)$ is sampled at minimum sampling frequency and we want to reproduce 15 minutes of the waveform.

[4 marks]

Question 2

(a) A signal $x(t)$ with a bandwidth of 4.5 MHz is sampled, quantized, and binary coded to obtain a pulse code modulation (PCM) signal. Assume that the signal is sampled at a rate 10% above the Nyquist rate and the sampled signals are quantized into 4096 levels using a uniform quantizer.

(i) Compute the number of bits required to encode each sample.

[1 mark]

(ii) Calculate the bit rate of the binary-coded signal.

[3 marks]

(b) Delta modulation is subject to slope overload distortion and granular noise. With the aid of diagram, explain the concept of slope overload distortion and granular noise. Next, suggest a method to mitigate these impairments.

[5 marks]

Continued .....

Question 2

(c)(i) State the main function of a matched filter at the receiver.

[2 marks]

(c)(ii) Explain the relationship of the impulse response of a matched filter with respect to its input signal.

[2 marks]

(c)(iii) For a message signal waveform $s(t)$ shown in Figure Q2, sketch the impulse response (in the time domain) of a matched filter to be used.

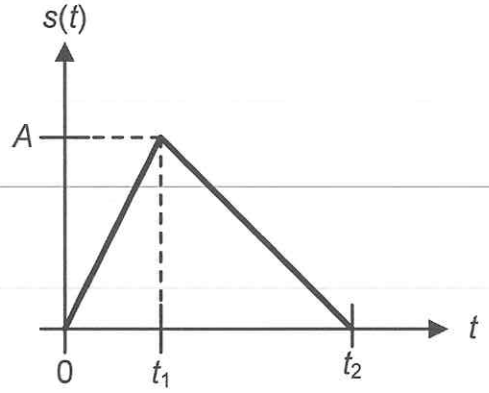

Figure Q2

[4 marks]

(d) A digital communication system transmits binary data at the rate of 20 Mbit/s using raised cosine roll-filter characteristic and 16-level pulse amplitude modulation (PAM).

(i) Compute the symbol rate.

[2 marks]

(ii) Calculate the minimum transmission bandwidth required to avoid inter-symbol interference (ISI).

[3 marks]

(iii) How large can the filter roll-off factor be if the system bandwidth is 2.75 MHz?

[3 marks]

Continued .....

Question 3

(a) Sketch the constellation diagram for the following modulation schemes:
(i) 8-phase shift keying (PSK).

[1.5 marks]

(ii) 16-quadrature amplitude modelation (QAM).

[1.5 marks]

(b)(i) For a binary data sequence of 1010001101, sketch the bandpass modulated waveform for binary PSK (BPSK) modulation. You can make appropriate assumption on the bit-to-symbol mapping.

[3 marks]

(b)(ii) State one advantage of $\pi/4$-quadrature PSK ($\pi/4$-QPSK) over QPSK.

[2 marks]

(c) Distinguish between coherent demodulation and noncoherent demodulation.

[3 marks]

(d) With the aid of diagram, explain the working principle of a baseband spread-spectrum receiver used for detecting direct-sequence spread spectrum (DS-SS) signals.

[7 marks]

(e) A block code consists of the following codes: 00000, 01110, 11101, 10011.
(i) Is this a linear code? Justify your answer.

[3 marks]

(ii) Find the number of errors that can be detected by this code.

[2 marks]

(iii) Determine the number of errors that can be corrected by this code.

[2 marks]

Continued .....

Question 4

(a) Explain the main difference between block codes and convolutional codes in terms of the processing sequence of the information bits.

[2 marks]

(b) With the aid of diagram, explain the working principle of concatenated codes.

[4 marks]

(c) Consider the convolutional encoder illustrated in Q4(c).

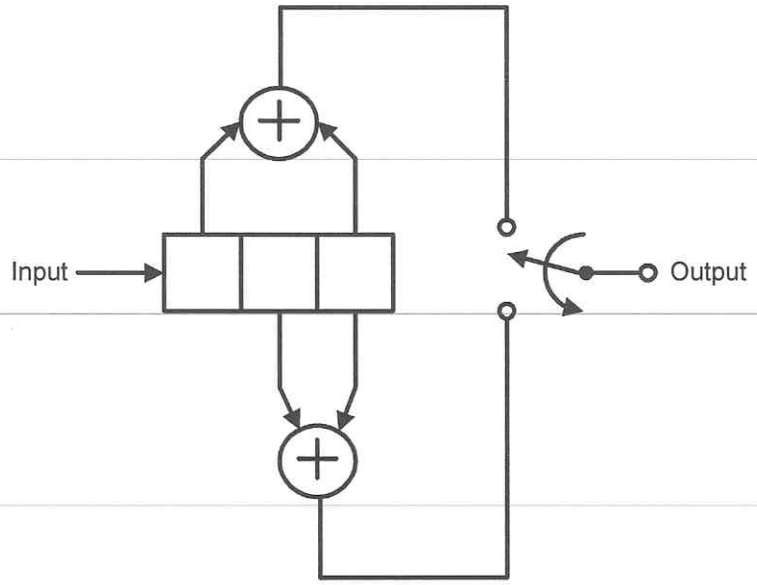

Figure Q4(c)

(i) Determine the generator polynomials and the code rate of the code.

[4 marks]

(ii) Sketch the state diagram.

[4 marks]

(iii) Sketch the trellis diagram.

[4 marks]

Continued .....

Question 4

(d) Consider the two 8-point quadrature amplitude modulation (QAM) signal constellations shown below. The minimum distance between points is $2A$. Determine the average transmitted power for each constellation, assuming that the signal points are equally probable. Which constellation is more power-efficient? Justify your answer.

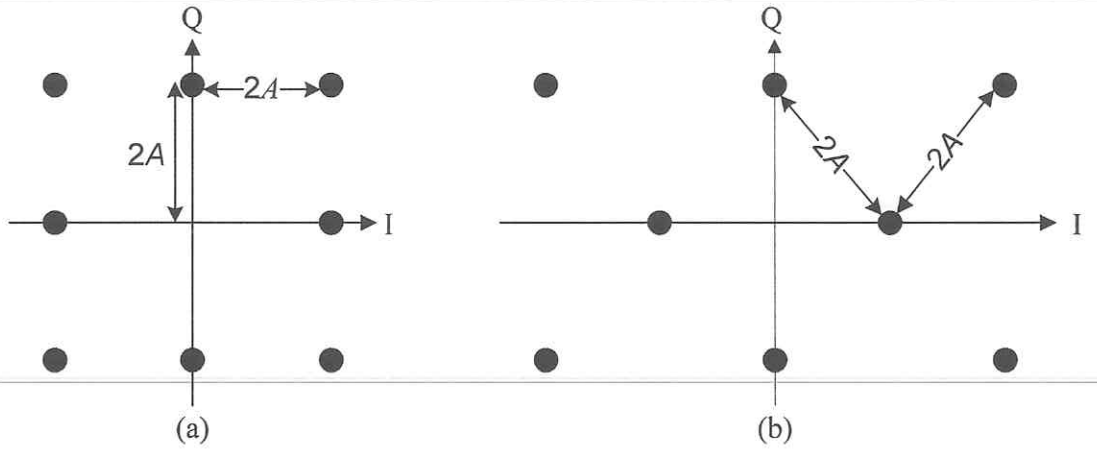

Figure Q4(d)

[7 marks]

Continued .....

Appendix 1: Table of Fourier Transform Properties

Let $x(t) \Leftrightarrow X(f)$, $x_1(t) \Leftrightarrow X_1(f)$ and $x_2(t) \Leftrightarrow X_2(f)$; and a, b, t_o and f_o scalar quantities.	
Linearity	$ax_1(t)+bx_2(t) \Leftrightarrow aX_1(f)+bX_2(f)$
Scaling ($a \neq 0$)	$x(at) \Leftrightarrow \frac{1}{\lvert a \rvert} X\left(\frac{f}{a}\right)$
Time Shifting	$x(t-t_o) \Leftrightarrow X(f)e^{-j2\pi f t_o}$
Frequency Shifting	$x(t)e^{j2\pi f_o t} \Leftrightarrow X(f-f_o)$
Time Convolution	$x_1(t)*x_2(t) \Leftrightarrow X_1(f)X_2(f)$
Frequency Convolution	$x_1(t)x_2(t) \Leftrightarrow X_1(f)*X_2(f)$
Time Differentiation	$\frac{d^n}{dt^n}x(t) \Leftrightarrow (j2\pi f)^n X(f)$
Frequency Differentiation	$(-jt)^n x(t) \Leftrightarrow \frac{d^n}{df^n}X(f)$
Time Integration	$\int_{-\infty}^{t} x(\tilde{t})d\tilde{t} \Leftrightarrow \frac{X(f)}{j2\pi f}+\frac{1}{2}X(0)\delta(f)$
Frequency Integration	$x(t)u(t) \Leftrightarrow \int_{-\infty}^{f} X(\tilde{f})d\tilde{f}$

End of Paper